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TECHNICAL REPORT ARLCD-TR-84025

U.S. ARMY ELECTROMAGNETIC LAUNCHER FACILITY

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JANUARY 1985



U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER

LARGE CALIBER WEAPON SYSTEMS LABORATORY

DOVER, NEW JERSEY

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Homopolar generator	Pulsed power supply	Continuous wave
Digitizer	Isolation amplifier	x-ray
Sabot	Capacitor bank	Soft catch
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
<p>The Electromagnetic Launcher Facility at ARDC is described. Experimental equipment, including the laboratory's 17.5 MJ railgun testbed and support hardware, are detailed.</p>		

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CONTENTS

	Page
Introduction	1
Discussion	1
Design	1
Instrumentation	1
Range and Diagnostics	2
Capacitor Banks	2
References	3
Distribution List	23

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FIGURES

	Page
1 Schematic of electromagnetic railgun	5
2 17.5 MJ launcher at ARDC, Dover	6
3 Experimental launch package	7
4 Nicolet with current trace	8
5 Nicolet with generator voltage trace	9
6 Schematic of railgun instrumentation	10
7 Transformer coupled isolation amplifiers	11
8 3.65 m long, low vacuum range	12
9 A 150 keV flash x-ray unit	13
10 Foil make switch	14
11 Experimental launch package in flight	15
12 High-speed photograph of muzzle arc from a low current shot	16
13 cw x-ray	17
14 107 cm long vacuum catch tank	18
15 Remnants of experimental launch package shown in figure 11	19
16 50 kJ capacitor bank	20
17 Common control system	21
18 Schematic of 4:1 pulse transformers	22

INTRODUCTION

The Armament Research and Development Center (ARDC) is responsible for developing new armament systems for the U.S. Army. Electromagnetic Launch Technology is a section within the Propulsion Technology Branch, Applied Science Division, of the Large Caliber Weapons Systems Laboratory.

This section was formed in 1977 to investigate novel gun propulsion concepts capable of future weaponization. ARDC and the Defense Advanced Research Projects Agency (DARPA), Arlington, VA jointly funded a major portion of the Electromagnetic Gun Program under which a compact homopolar generator (HPG) was developed, electrical current collection technology was advanced, and the fastest and largest electromagnetic guns were built.

The present emphasis of the facility is development of electromagnetic launcher components. The ARDC facility is available to the electromagnetic launch research community to test components, instrumentation, and diagnostic devices.

DISCUSSION

Design

The simplest method of electromagnetically propelling a round employs an armature placed between two parallel conducting rails (fig. 1). The Lorentz forces generated by the interaction of the magnetic fields and currents accelerate the armature and any attached mass down the bore of the railgun. Prior to the design of the 17.5 MJ launcher for the U.S. Army, railgun experiments were conducted at the Australian National University (ANU) (ref 1) and at the Westinghouse Research and Development Center (refs 2 and 3). The design of the launcher owes much to research performed at those facilities.

The 17.5 MJ launcher at ARDC was designed and constructed by the Westinghouse Electric Corporation as part of the ARDC/DARPA electromagnetic propulsion program (fig. 2). Primary energy storage is a truncated drum, 150 V, 2 MA HPG that is driven with a variable speed AC-induction motor drive. This HPG energizes a 4.5 μ H four-start toroidal air core inductor. A single shot, double pole opening switch delivers current to the 50-mm-square bore, 5-m long, parallel rail barrel. The launch package currently being used consists of bundled copper fibers held in place with a Kevlar sabot structure (fig. 3).

Instrumentation

Data from the launcher are presently recorded with Nicolet and Biomation transient waveform digitizers which have maximum sampling rates of 2 MHz and 5

MHz, respectively (figs. 4 and 5). These devices are being replaced with a Tektronix Signal Processing System (SPS). This new data acquisition system uses a Digital Electrical Corporation PDP 11/34a computer and Tektronix 390AD digitizers to record and to analyze data. A Lindgren RF enclosure shielded by a 1-inch armor wall houses this SPS.

Electrical data are measured with voltage and induction probes at various locations in the launcher circuit (fig. 6). High induction fields of the pulsed power supply require the use of transformer coupled isolation amplifiers to reject the large common-mode voltage of the launchers (fig. 7). These devices have a 1% small-signal gain linearity over a 20 kHz band with phase linearity. The measured parameters are used to assess the performance of the launcher.

Range and Diagnostics

Presently the facility has a 3.65-m-long, low vacuum range which is sufficient for the present component development work (fig. 8). A 150-keV flash x-ray unit (fig. 9) triggered by foil make switches (fig. 10) has been used with moderate success to document launch package integrity (fig. 11). To obtain reliable triggering in the muzzle-zone (fig. 12), a continuous wave x-ray trigger (fig. 13) will be installed to replace the foil triggers.

A 107-cm-long vacuum catch tank (fig. 14) with a 38-cm-square cross section terminates the range. This tank has a 20-cm-diameter aperture and can be filled with 58 cm of metal or with a 60-cm-long target. We have attempted to soft catch launch packages of 550 g at 600 m/s with moderate success (fig. 15).

Capacitor Banks

Five 50-kJ capacitor banks (fig. 16) which individually have a 100-kA output are routinely used for small experiments. A common control system for simultaneous operation of the banks is being installed (fig. 17). Pulse transformers are being designed to increase the combined output of these banks to 1.8 to 2.0 MA (fig. 18). This high current stand will be used to test the electromechanical performance of the new components as well as to generate pulsed high magnetic fields.

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1. R. A. Marshall, "Moving Contacts in Macro-Particle Accelerators," proceedings of the Australian Seminar on Energy Storage, Compression and Switching, 15 - 20 November 1977, High Power, High Energy Pulse Production and Application, E. Inall, ed., ANU Press, Canberra, Australia, pp 216 - 230, 1978.
2. I. R. McNab, et al., "DC Electromagnetic Launcher Development: Phase I," ARDC Contractor Report ARLCD-CR-80009, Westinghouse Electric Corporation, Pittsburgh, PA, May 1980.
3. D. W. Deis, D. W. Scherbarth, and G. L. Ferrentino, "EMACK Electromagnetic Launcher Commissioning," paper presented at Second Symposium on Electromagnetic Launch Technology, Boston, MA, 10-13 October 1983, published in IEEE Transactions on Magnetics, vol MAG-20, no. 2, March 1984, pp 245-248.

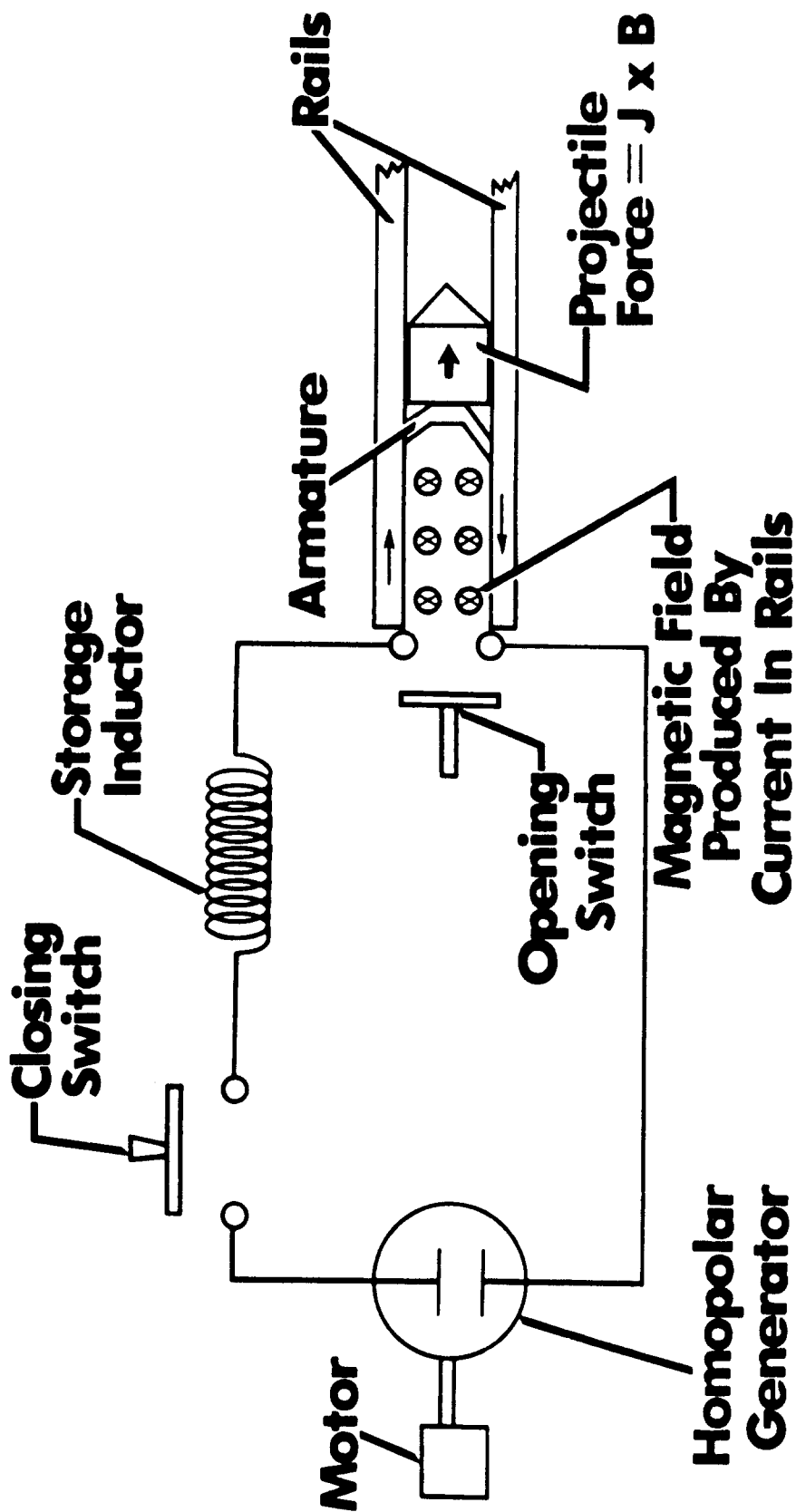


Figure 1. Schematic of electromagnetic railgun

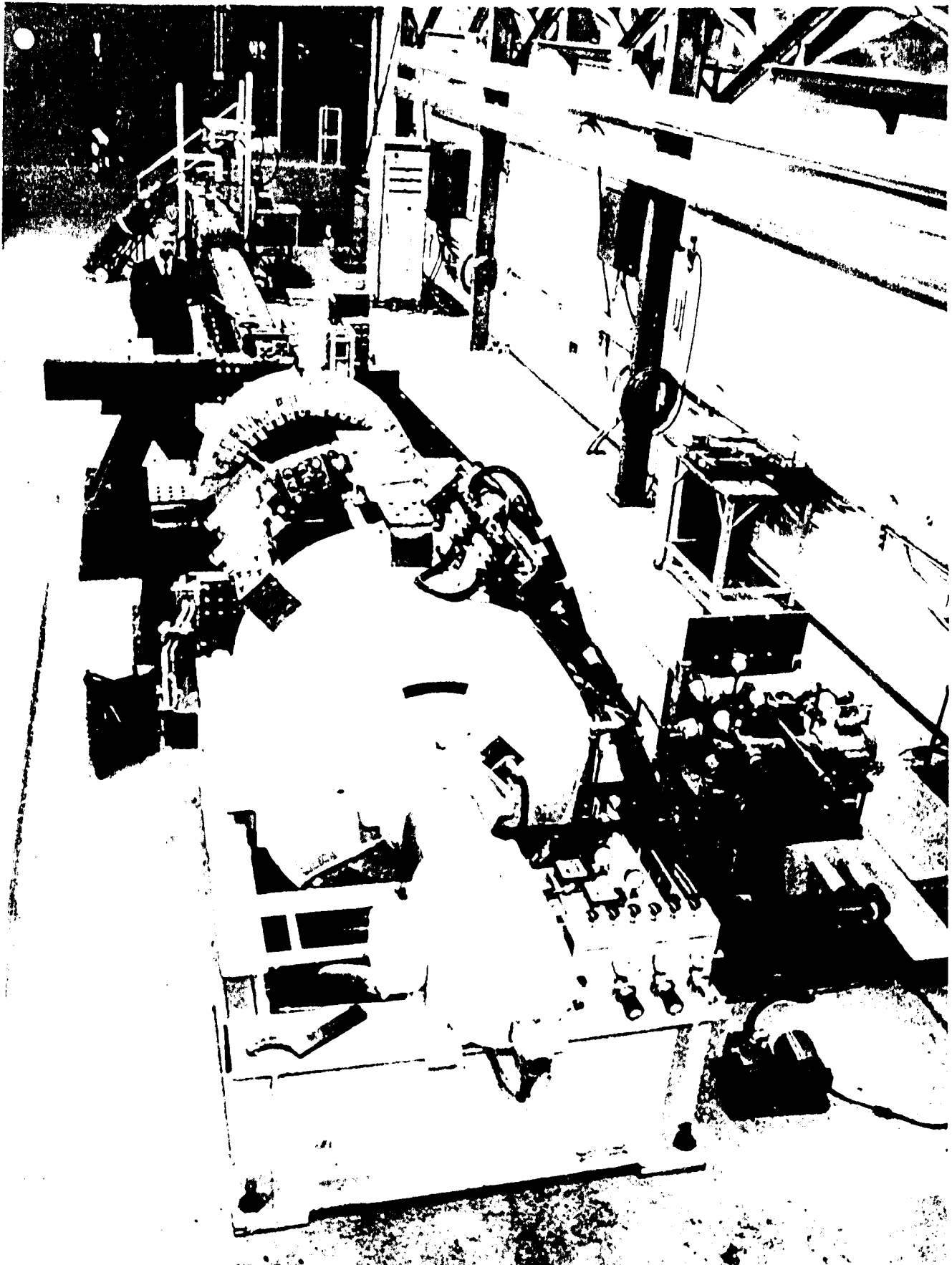


Figure 2. 17.5 MJ launcher at ARDC, Dover

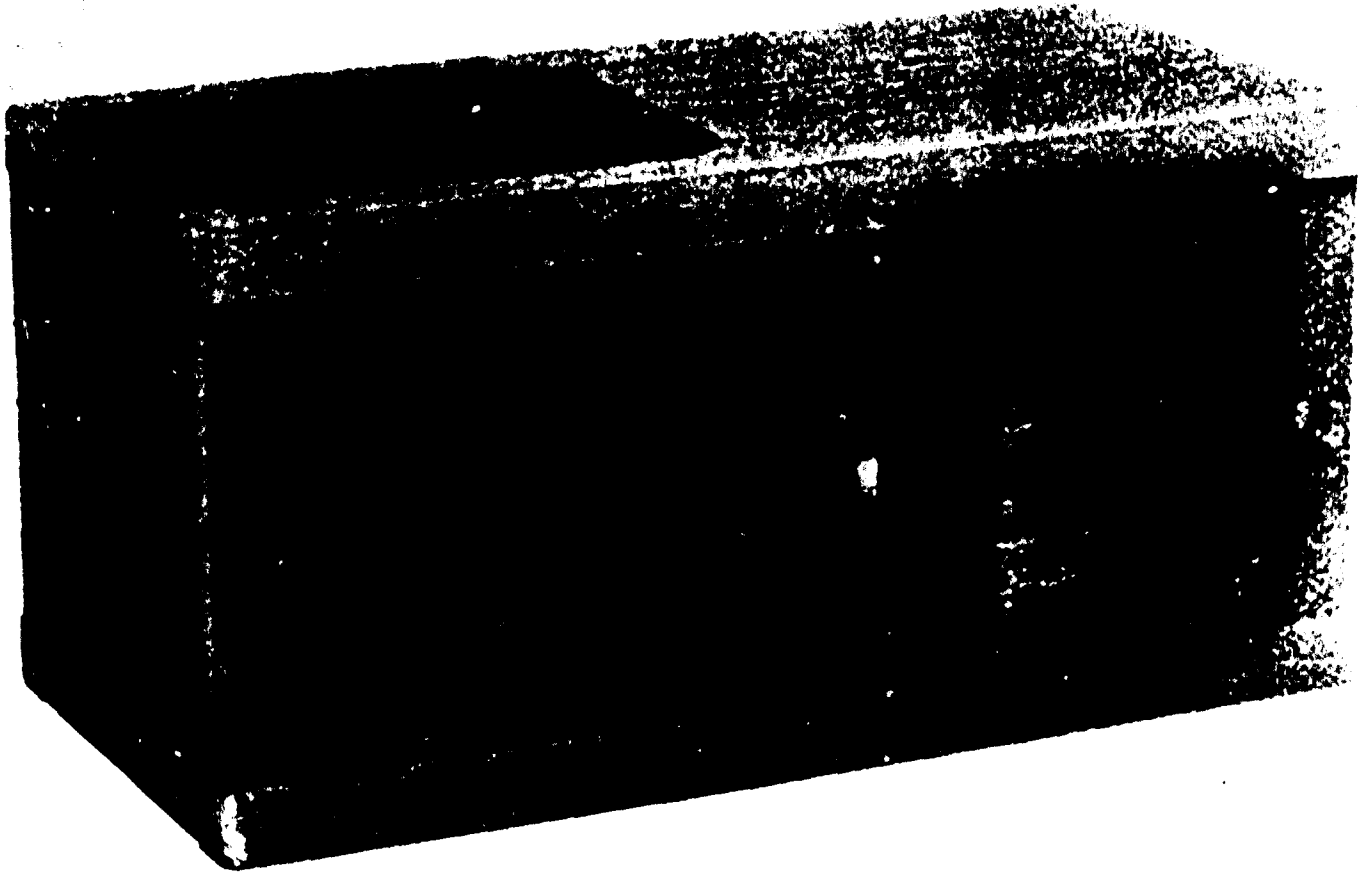
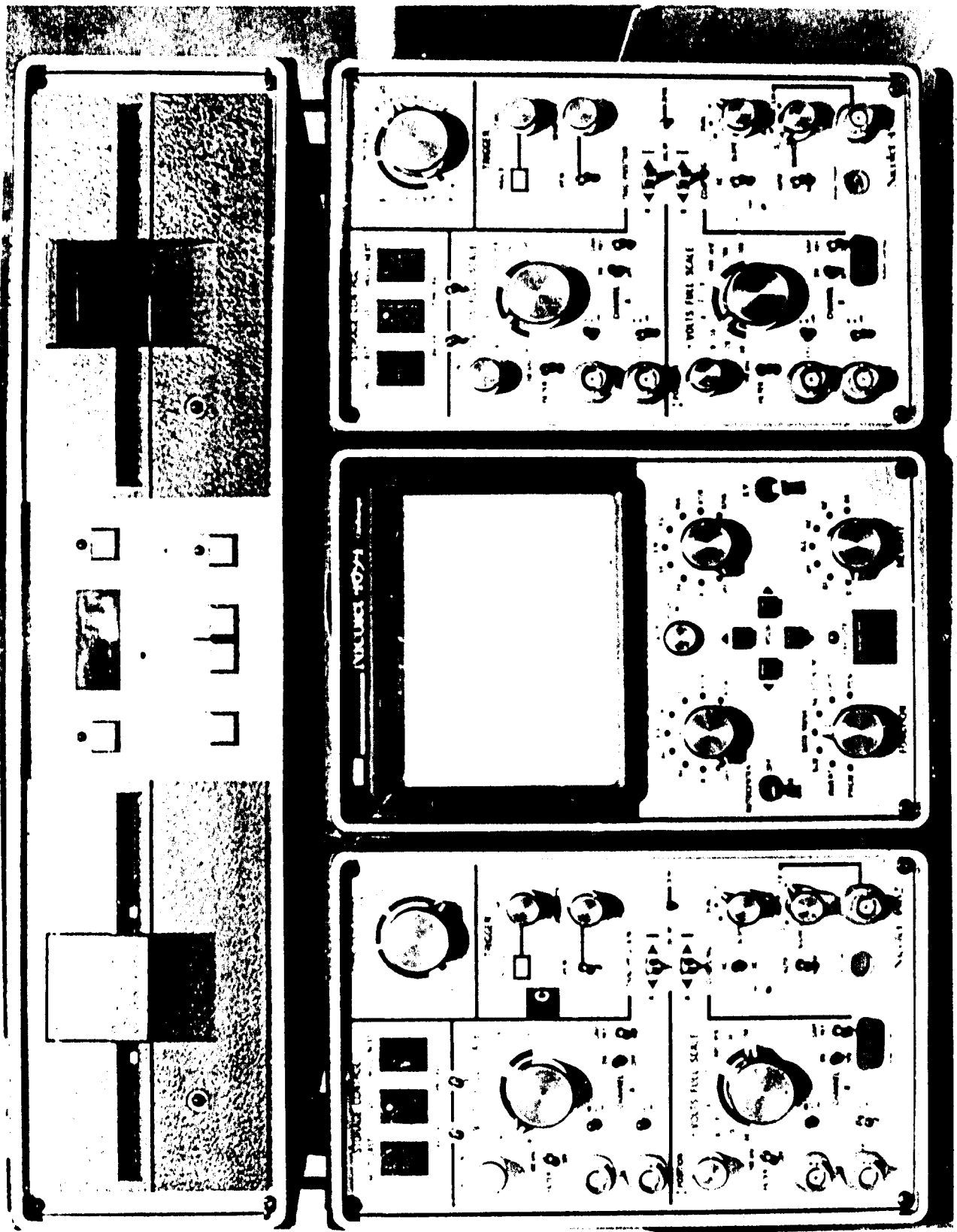


Figure 3. Experimental launch package

Figure 4. Nicolet with current trace



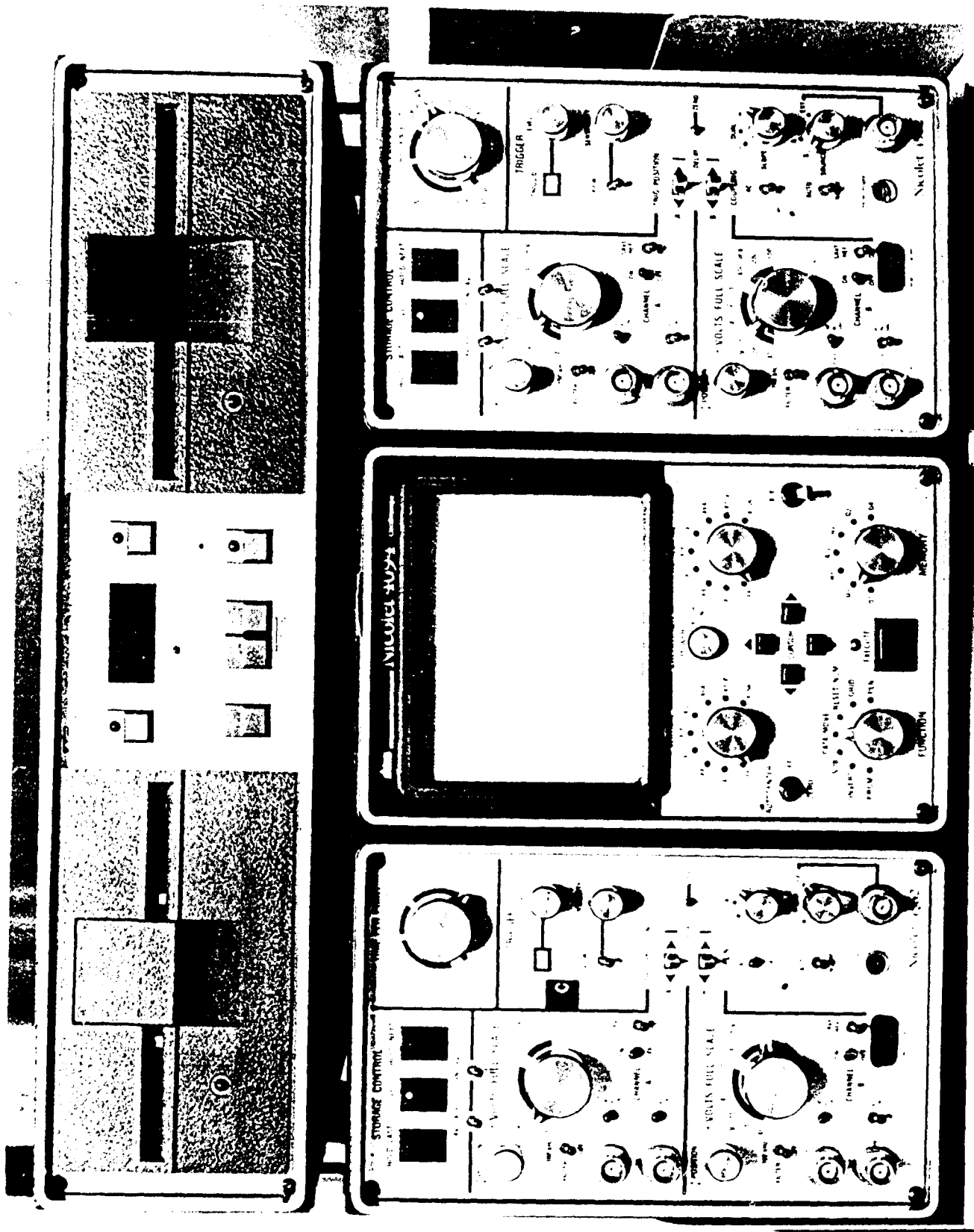
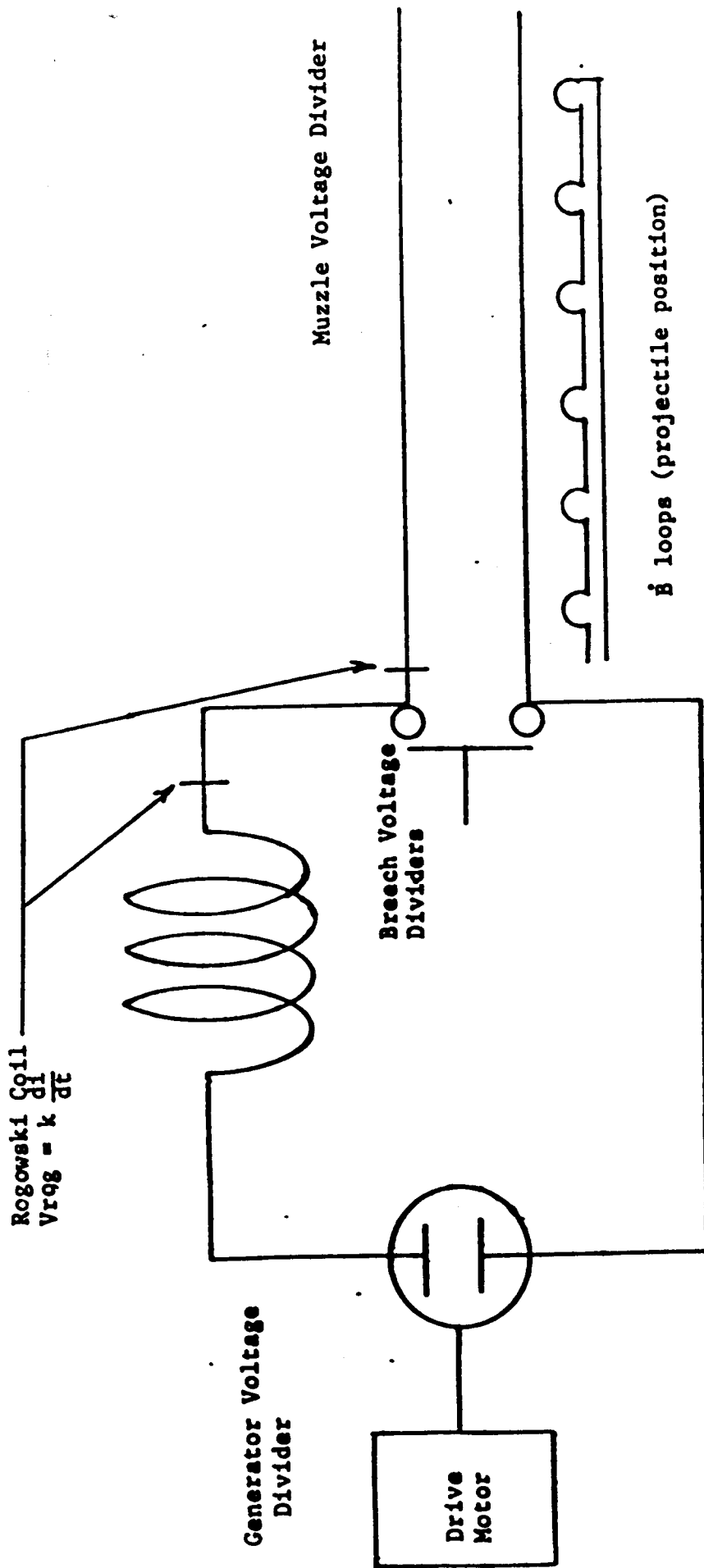


Figure 5. Nicolet with generator voltage trace



Range Diagnostics

Flash X-Ray
High Speed Motion Photography
Post Mortem

Figure 6. Schematic of railgun instrumentation

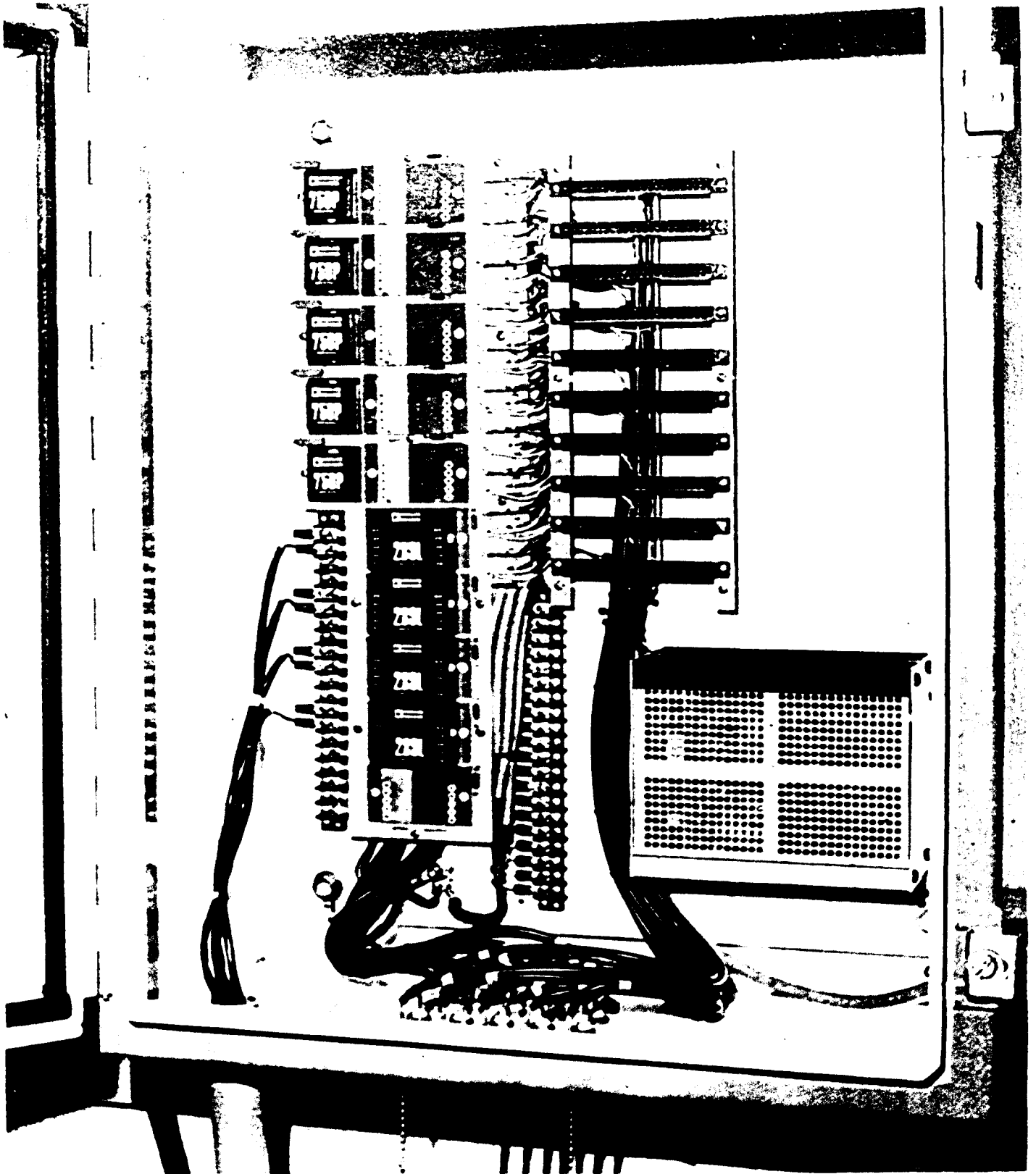


Figure 7. Transformer coupled isolation amplifiers

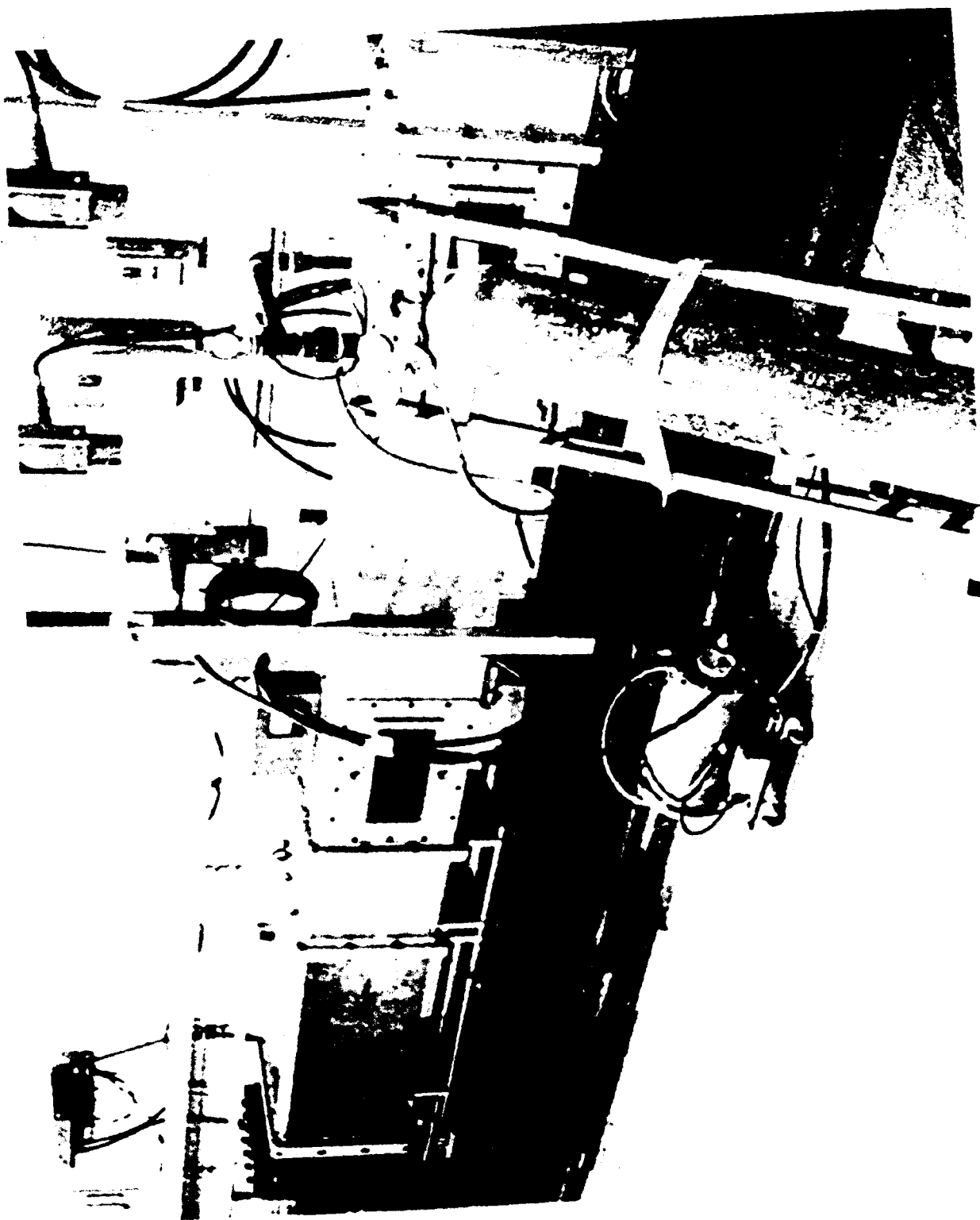


Figure 8. 3.65 m long, low vacuum range

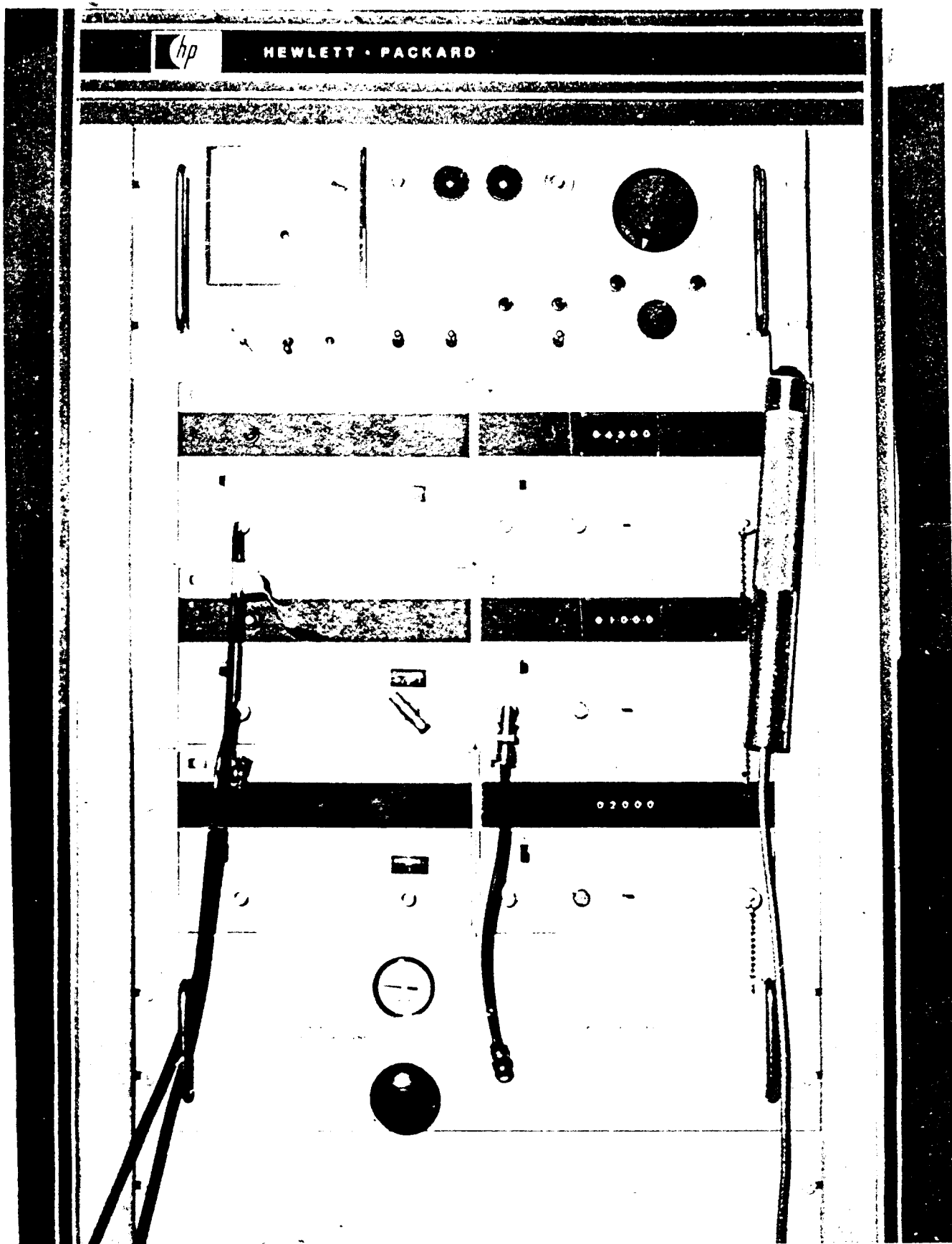


Figure 9. A 150 keV flash x-ray unit

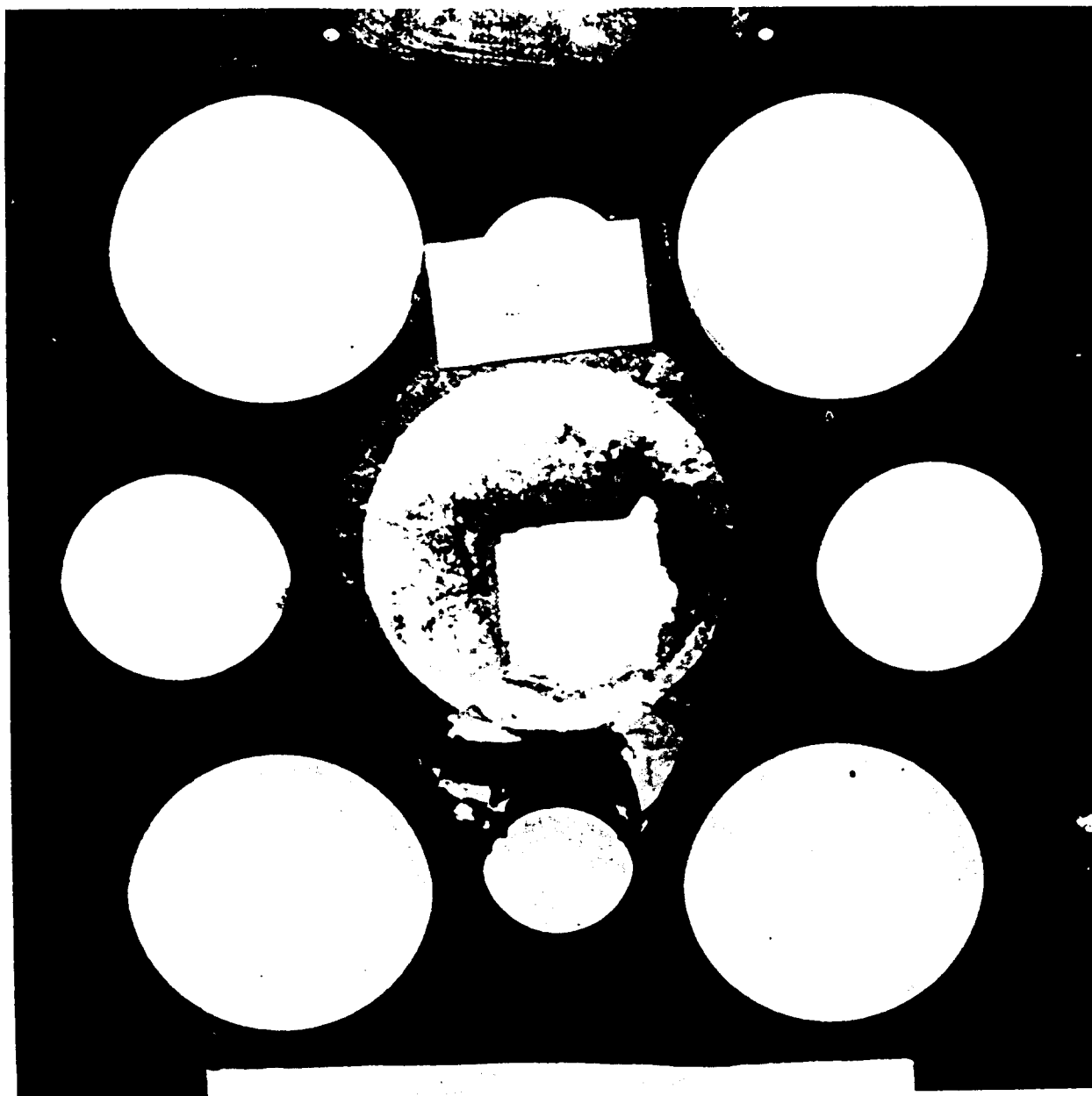


Figure 10. Foil make switch

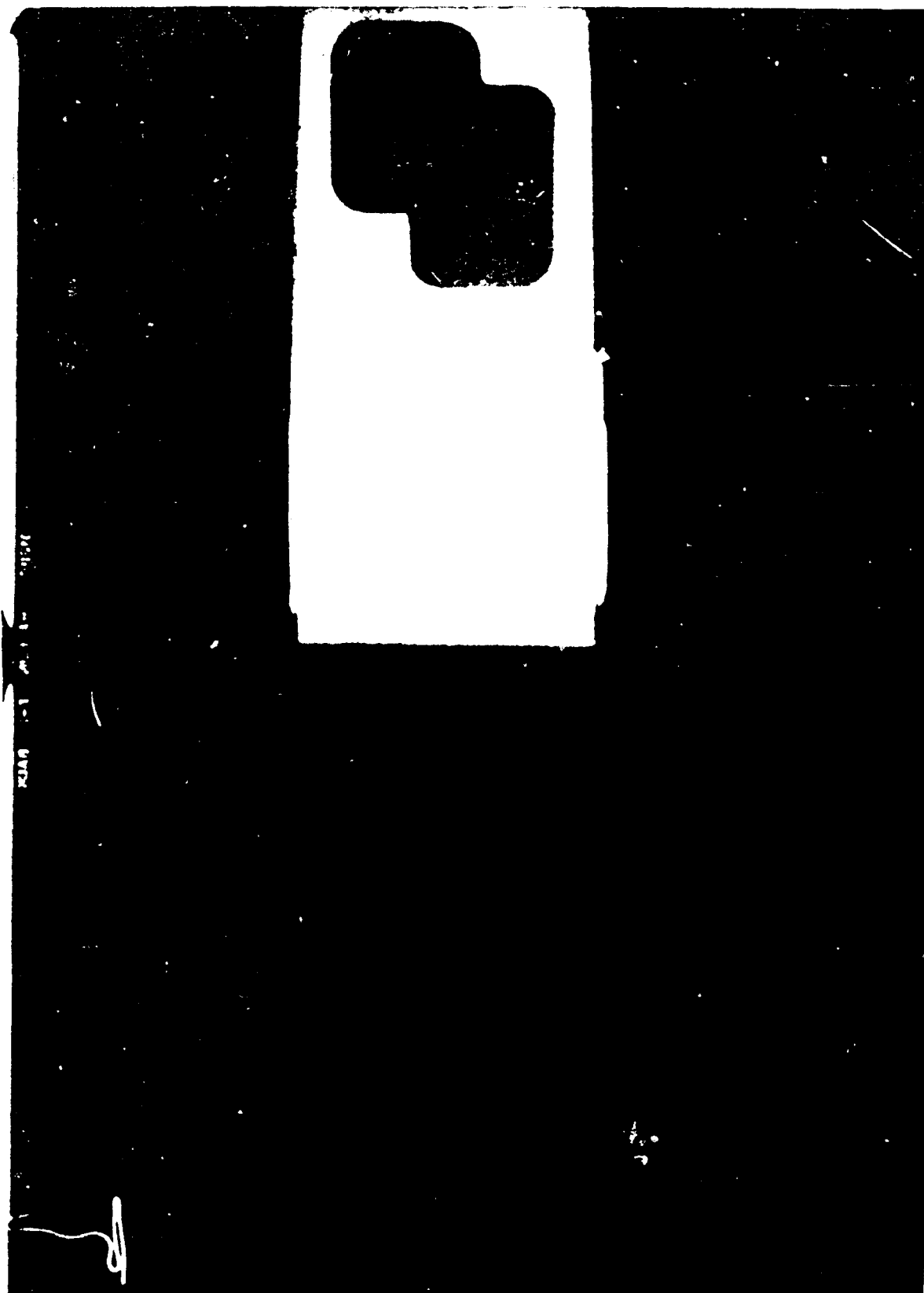


Figure 11. Experimental launch package in flight

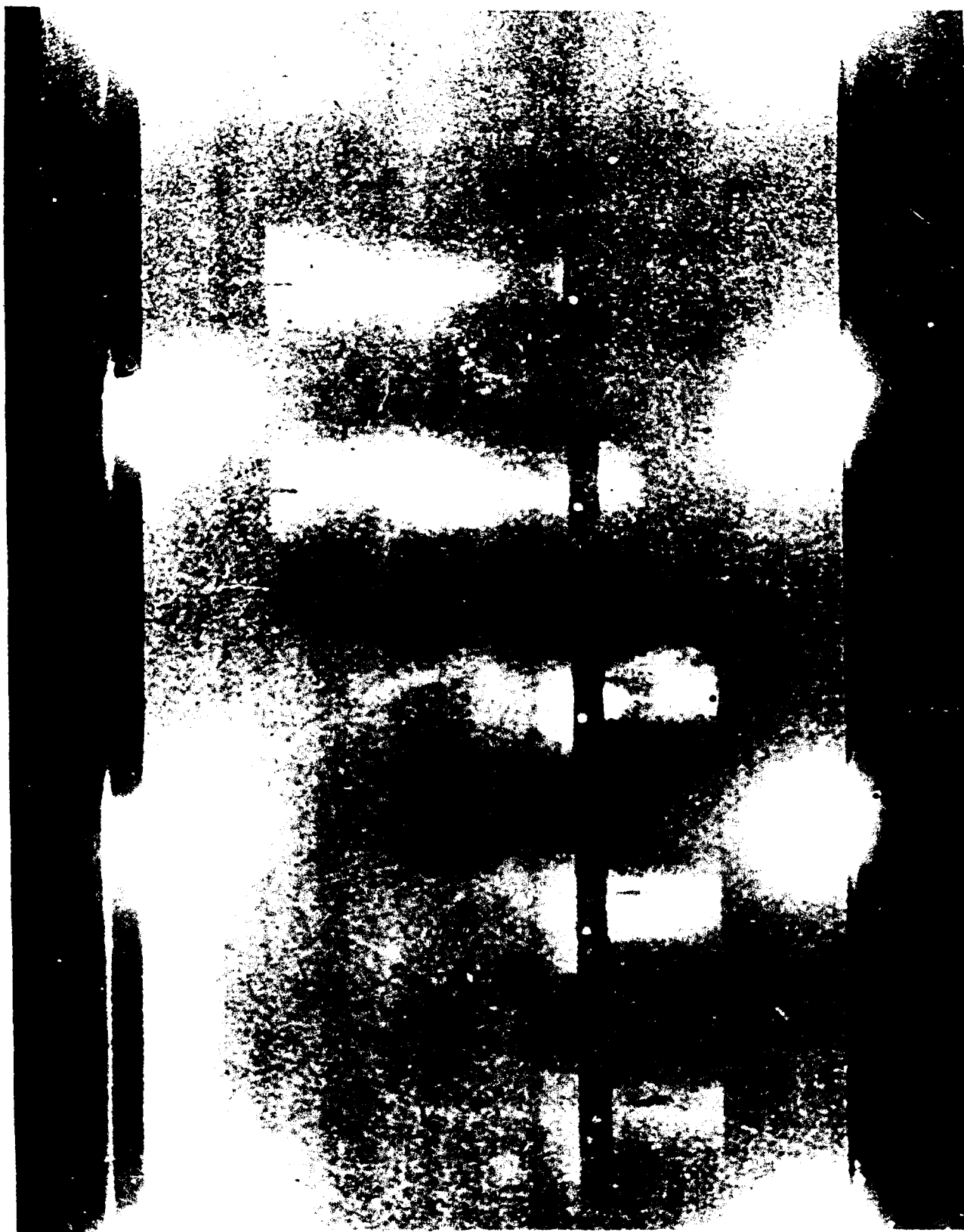


Figure 12. High-speed photograph of muzzle arc from a low current shot

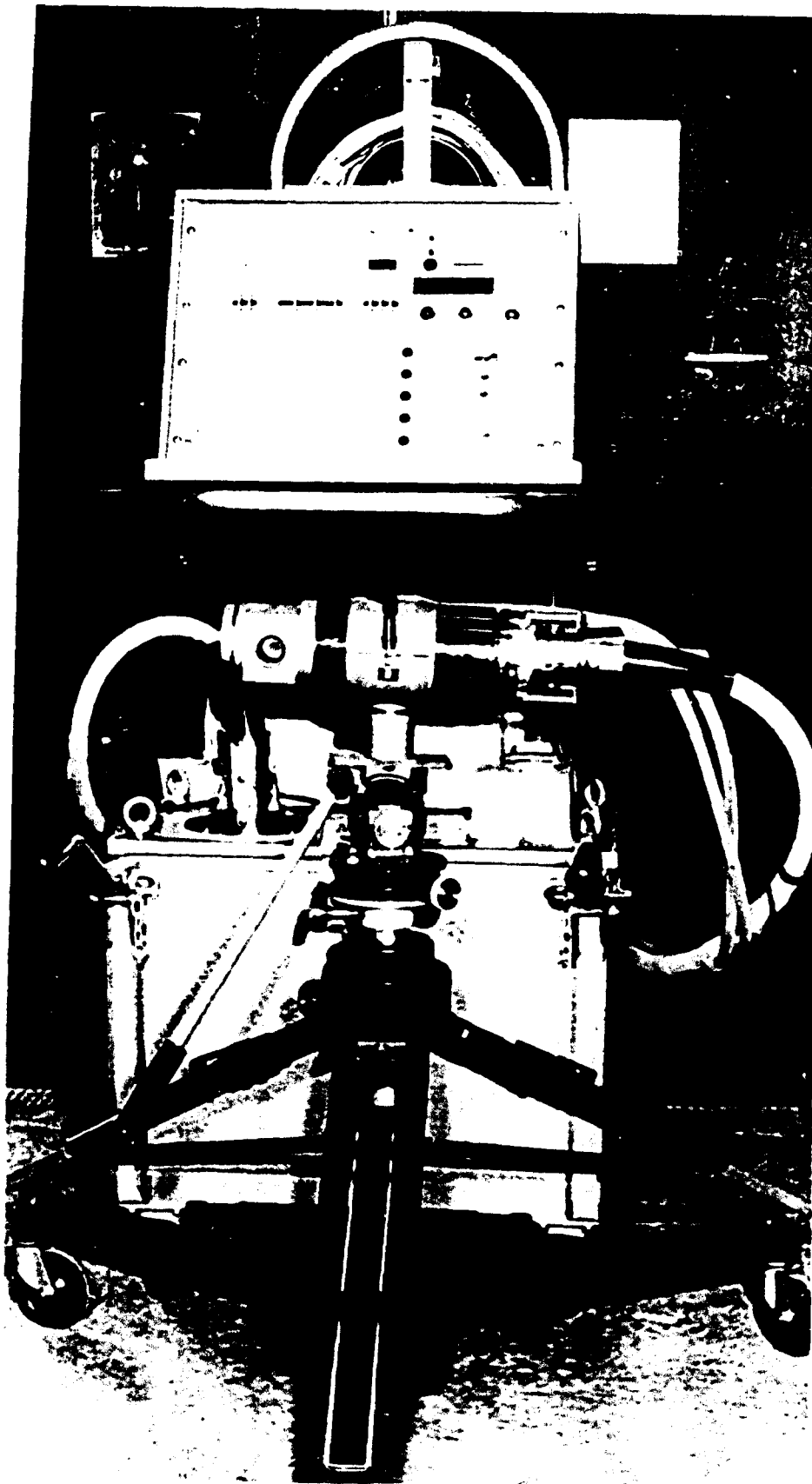


Figure 13. cw x-ray

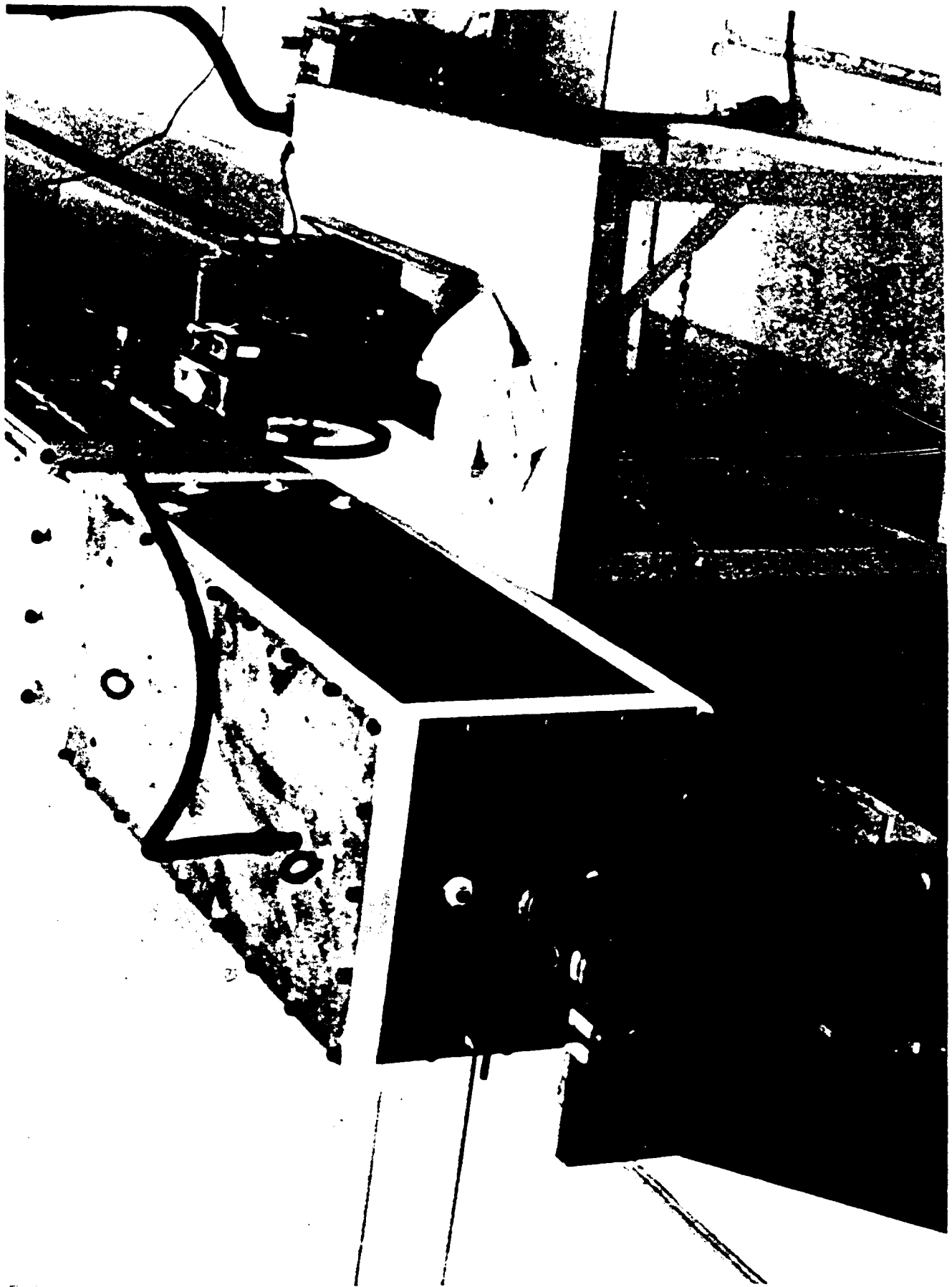


Figure 14. 107 cm long vacuum catch tank

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Figure 15. Remnants of experimental launch package shown in figure 11

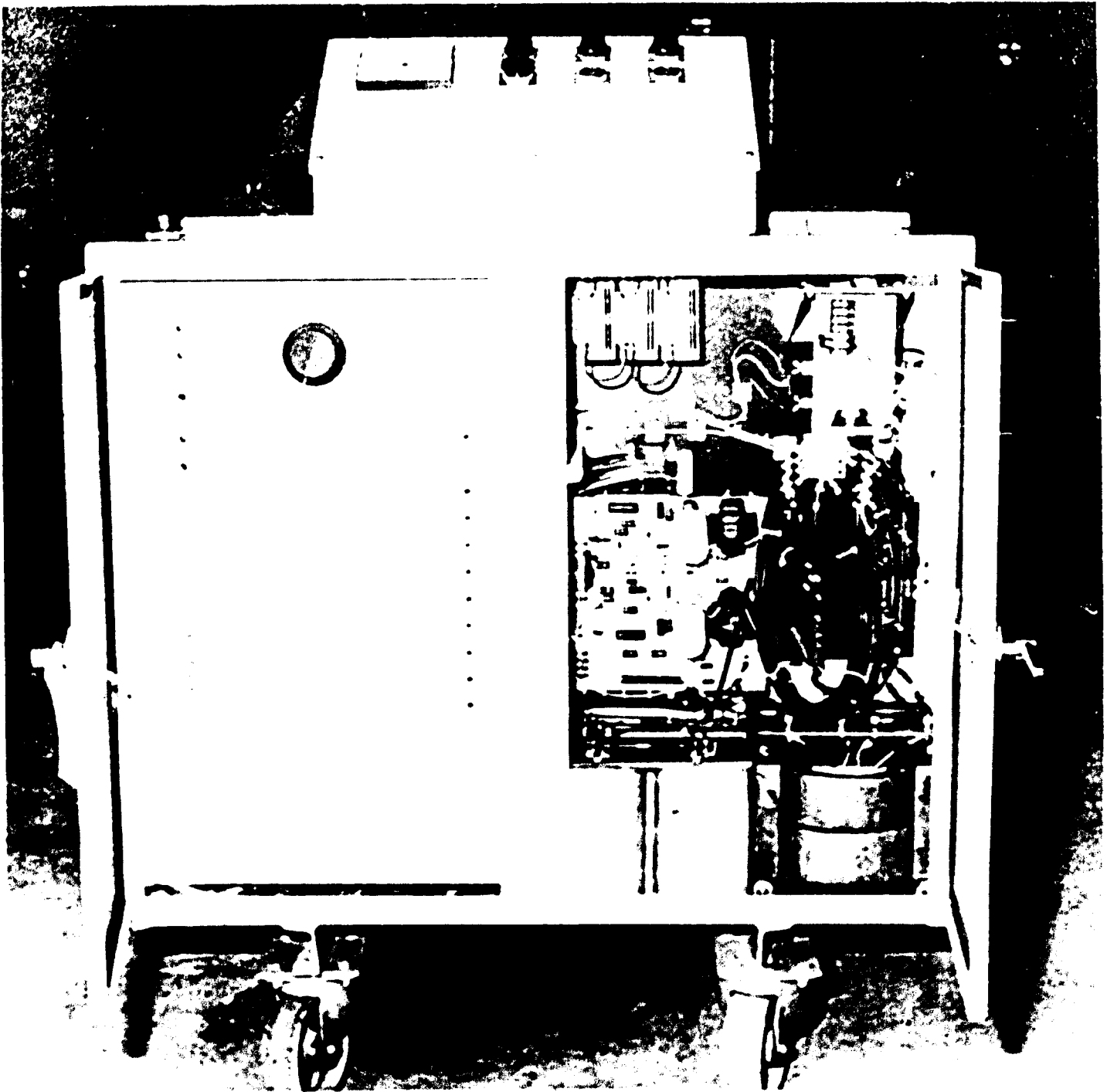


Figure 16. 50 kJ capacitor bank

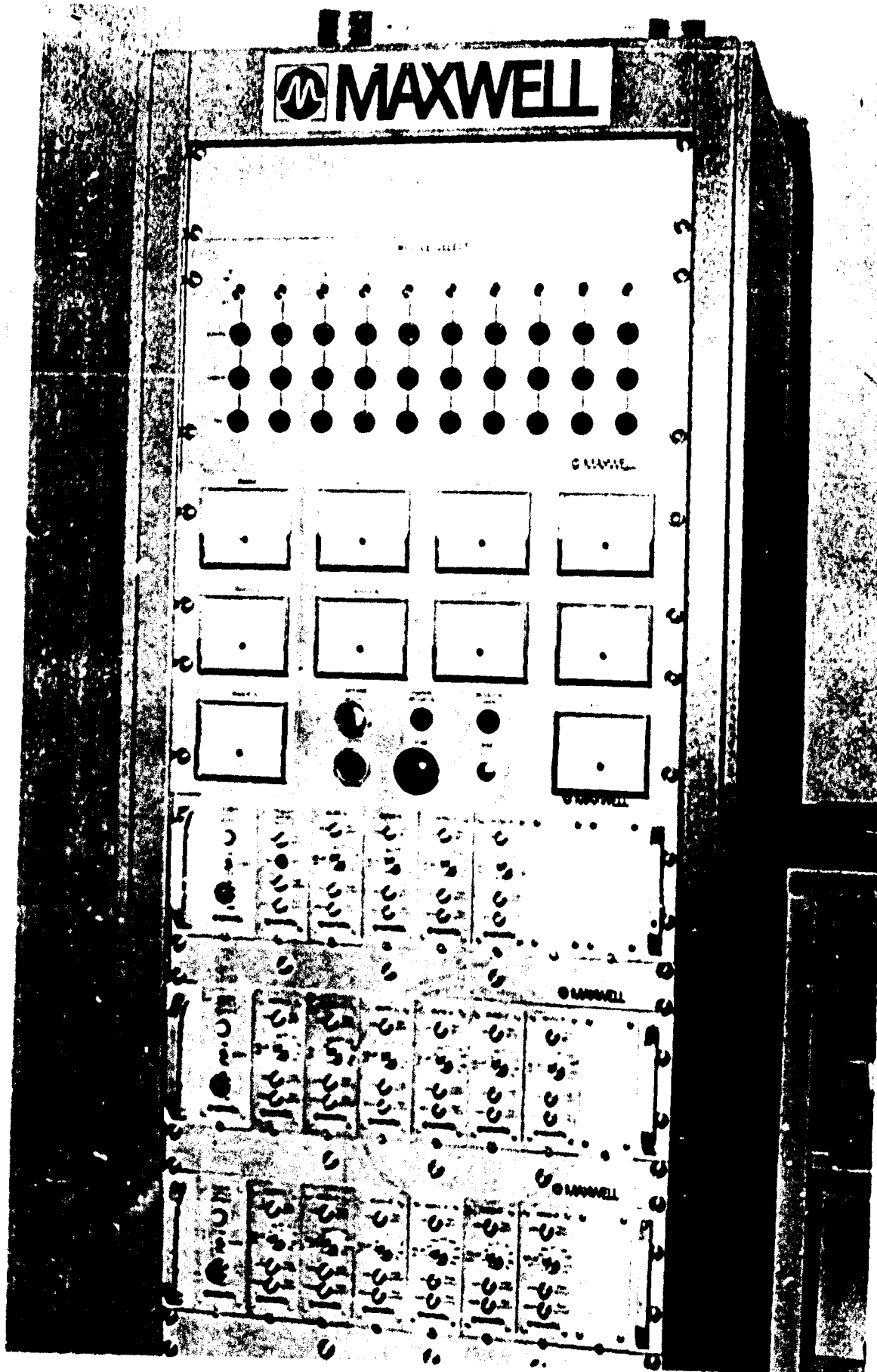
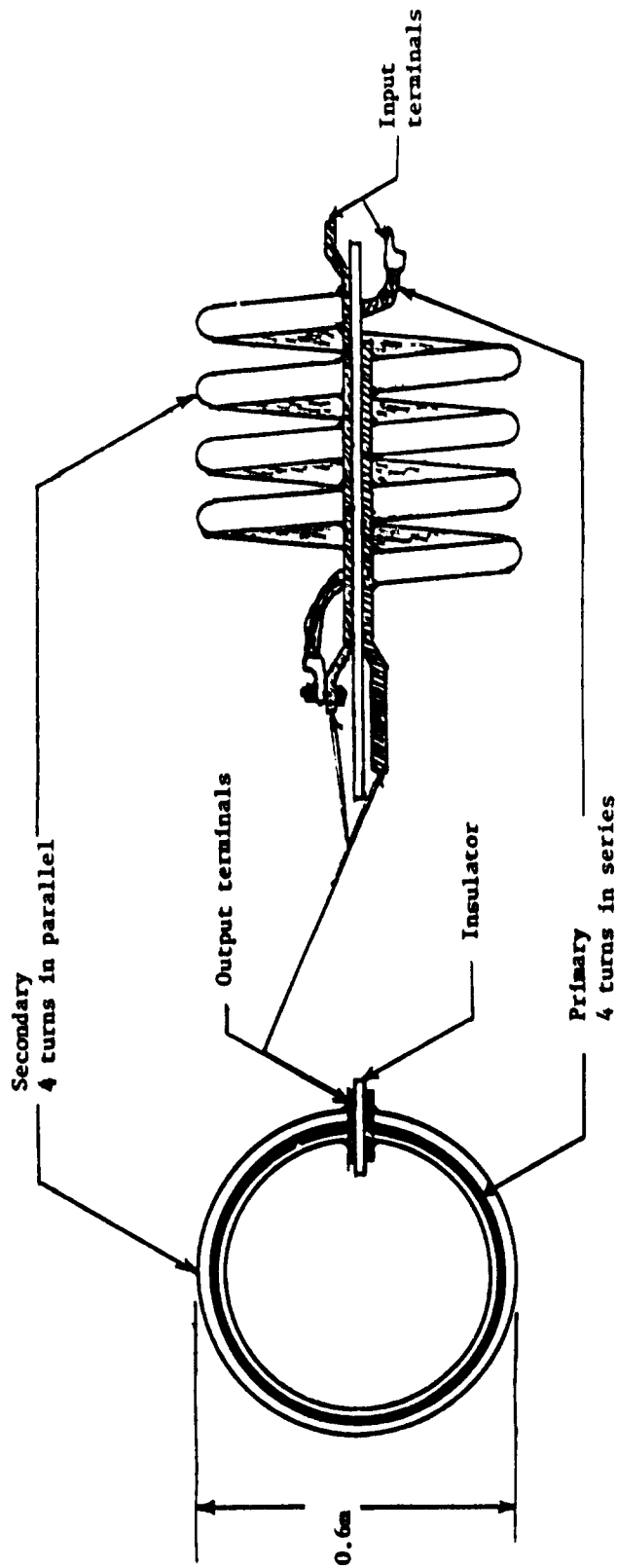


Figure 17. Common control system



The original drawing was prepared by
William Weldon, Center for
Electromechanics, University of
Texas, Austin.

4:1 Current Step-up
Pulse Transformers

Figure 18. Schematic of 4:1 pulse transformers

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